The Role of Insects in the Forest

John Bernhard Smith

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BY

JOHN B. SMITH, State Entomologist

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The Role of Insects in the Forest.

By JOHN B. SMITH, Sc.D.

That a giant of the forest, one that has resisted the storms of a century, should succumb to the attacks of an insect, countless millions of which would be required to equal it in bulk, seems almost absurd; yet it is nevertheless true, though not, as a rule, quite so literally as it reads. Most of our forest trees support an immense insect population without showing any ill effects. Nearly 500 species are known to feed on the species of oak, and nearly 200 on the species of pine, in the United States. Given a perfectly healthy tree, it will bring to maturity a host of feeders upon its foliage, upon the smaller shoots, in the injured or broken twigs or branches, in its fruit, and even in its woody tissue. Comparatively few borers or other insects are able to maintain themselves in the growing wood of large healthy trees, and when these occur in moderate numbers they inflict only such wounds as are easily healed, corresponding to mere scratches in the human skin. Under some conditions these insects increase abnormally, and then thousands of acres of timber may be killed off. As the bleeding from many small scratches may drain the human body of blood when they are kept constantly open, so the boring of thousands of beetles, insignificant individually, may weaken even the forest giant; and when this occurs, when there is no longer a healthy, resistant tissue, then another host of other species steps in, adds to the injury, and paves the way for yet further armies that complete the work, leaving only a dead stick with bare branches, sooner or later prostrated by a storm, and then slowly reduced to dust by yet other agencies, insect, fungous, or microbic in character.

Of the feeders upon foliage in its broad sense, some, like caterpillars, feed openly and simply upon the leaf tissue, destroy and

convert a certain amount of it into caterpillar tissue, and their work is done. Little impress is left upon the tree under ordinary conditions, or unless the feeding numbers are excessive. Even if one of the large species defoliates a branch, this is not serious except on conifers, which, on the whole, suffer less from attacks of this kind.

The larvæ of saw-flies are also feeders upon forest-tree foliage, and these sometimes do local injury. Saw-flies are Hymenoptera, *i. e.*, they belong with the bees, wasps and ants in structure; but they differ by having the abdomen closely joined to the body, not connected with it by a slender waist. Saw-fly larvæ resemble caterpillars in shape and appearance; but have at least 18 legs, instead of 16, as in true caterpillars. They have a tendency to feed in colonies and often curl up the end of the body when feeding at the edge of a leaf. A black-spotted species occurs on pine, sometimes in such numbers as to attract attention and defoliate even large branches. Small or ornamental trees in parks are sometimes killed or severely injured; but on larger trees a dead twig or small branch is the extent of the mischief caused.

Some of these larvæ are covered with a white powdery bloom, and at least one species, occurring on willow, becomes of considerable size, reaching an inch and a half in length when extended at full length. It is pale yellowish in general color, with a whitish, small head and a black stripe down the back, making it easily recognizable and a fair sample of this kind of larva except in size.

On the hickory and butternut other species occur that are known as "woolly worms," because of the masses of fine waxen threads that cover the body and give it a fluffy appearance.

Yet other species are gall-makers, causing blister or marble-like excrescenses on leaves, stems or twigs, in the center of which the larvæ feed. Willows and poplars are especially subject to this kind of attack.

Among the caterpillars, besides those that eat of the leaf-tissue directly, many are leaf miners, eating between the upper and lower surfaces, sometimes irregular blotches, sometimes galleries of definite form, each species having a constant and characteristic type. A few others make little cases or sacks, in which they live and which they carry about with them. Many are leaf-

rollers, folding or rolling the entire or part of a leaf into a cylinder, in which they feed under shelter. Yet others live in colonies and spin up a number of leaves or even an entire branch. The well known web-worms and tent caterpillars will readily occur to all, and wide-spread injury is sometimes done by one or both. The forest tent caterpillar has defoliated acres of forest land in New York State during the season of 1899, and has opened the way for yet more serious injury in 1900. Less known is another species that attacks young trees, often enveloping one of 4 or 5 feet completely. When this occurs the death of the young tree often follows, the growth being smothered where not actually eaten.

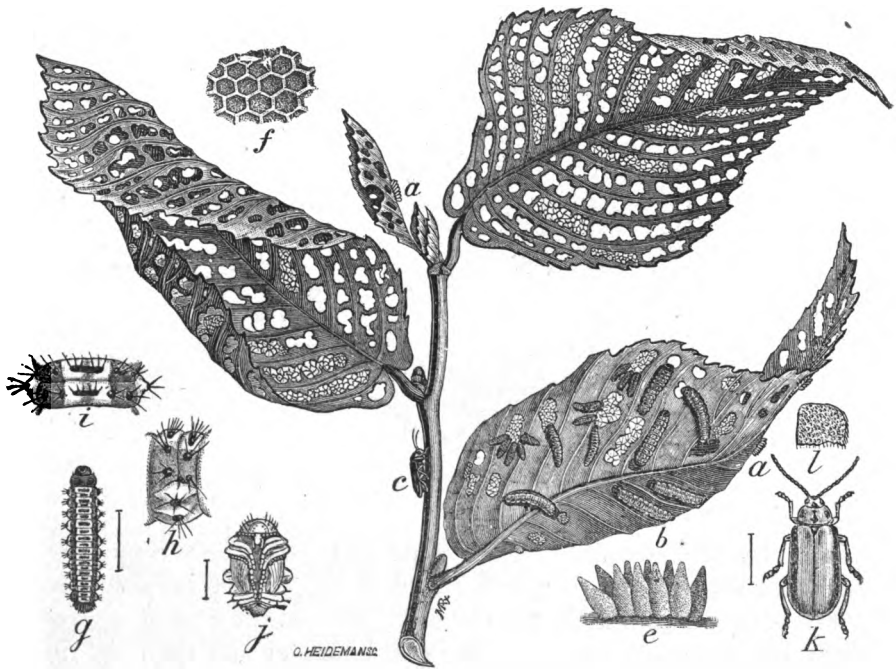

Figure 2.—Elm leaf beetle; typical of a destructive feeder on foliage: *a*, *a*, egg patches on leaves; *b*, larvæ feeding; *c*, adult; all natural size: *e*, egg-mass; *f*, surface of the egg; *g*, larva; *h*, *i*, details of the same; *j*, pupa; *k*, beetle; *l*, surface of elytra; all enlarged: from Div. Ent. U. S. Dept. Agl.

Numerous "grubs," or beetle larvæ, live on the leaves of forest trees, often in very large numbers, and these also may be open feeders, leaf miners or sac bearers; but they rarely become

as destructive as the Lepidopterous and Hymenopterous larvæ already mentioned.

Galls made by saw-fly larvæ have been already mentioned; but they are in the minority when compared with those made by others of the same order Hymenoptera, the *Cynipidæ* or true gall wasps. These galls may appear on almost any part of the tree when young; but, when older, trunks and larger branches are exempt: and they are as diverse as the places they attack. Oaks are favorite subjects, but other trees are by no means free from them.

On the leaves the galls are usually more or less spherical or marble-like, but they differ much in size and texture, being sometimes quite solid with thick walls, sometimes filled with

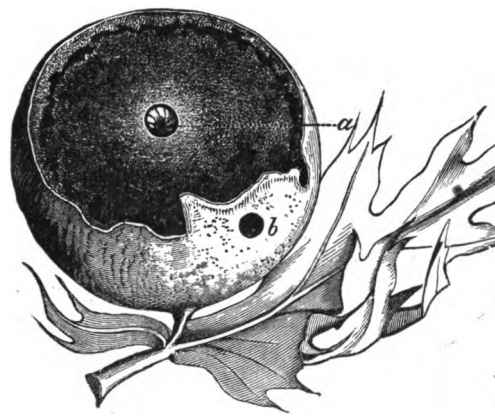

Figure 3.—A spongy oak gall: from Riley.

loose tissue and with a thin paper-like covering. Some are small and some are large, but that fact does not indicate the size of the larva that causes the gall. Two of the largest species occurring on oak exceed an inch in diameter and are filled, in the one case with a brown spongy mass, in the other with thread-like fibres radiating from the center in all directions to the outer wall.

On the twigs and branches the galls may be also marble-like in appearance or they may be mere swellings or other protuberances. One of the largest and most common forms occurs as a potato-like swelling on the trunks and branches of young and

twigs of older trees. It is fully 1¼ inches in diameter as a rule, and sometimes considerably more. Through the outer envelope comes, in due time, a series of pointed processes which are, each of them, larval cells: in other words, instead of the gall being produced by and containing only a single larva, some 50 to 100 have combined to form the larger swelling, in which each larva has a separate cell.

In some cases the very tips of the shoots become swollen and distorted, so that the gall is really a malformation of the shoot itself; or there may be a cluster of soft ovoid growths so close together as to press themselves out of shape and produce a series of irregular, more or less transversely flattened blisters.

More rarely galls occur on the roots, and these are usually irregular, lumpy swellings.

But not the Hymenoptera alone produce galls: quite a number of Diptera, or flies, belonging to the family *Cecidomyidæ* produce abnormal growths on leaves or twigs. One species attacks the base of the leaves of pines and causes an abnormal onion-like swelling at that point; quite a number are found making galls on the hackberry, while the willow is especially favored by them: all sorts of abnormal growths being produced, from little swellings to small cabbage-heads.

A few of the beetles are gall-makers—some on pine, like *Podapion gallicola*, others on deciduous trees—and these galls are usually mere swellings on the twigs or branches, in which the larvæ feed.

Phylloxera galls are common on hickories, and it is not an uncommon thing to see a young tree with the leaves covered with the large blister-like galls which are open inferiorly. If one of these galls be cut open, the inner surface will be found so crowded with the insects that they can scarcely find room to insert their beaks to obtain food.

Plant-lice, belonging to the same order as the *Phylloxera*, also produce more or less obvious gall-like growths, and the elm is a favorite tree for their attack. Sometimes there is a mere curling and distortion of the leaf, like that caused by *Schizoneura americana*, but often a real swelling, like the cocks-comb gall made by *Colopha ulmicola*, is produced.

It seems, thus, that most of the orders of insects outside of the Neuropterous series contain gall-makers, and all of them are, of

course, some sort of draft upon the tree. The least drain, perhaps, is made by the gall wasps, or *Cynipidæ*, where the larvæ seem to feed chiefly upon a secretion in the central cell and not upon the gall tissue itself.

Plant-lice have been mentioned as gall-makers, but they occur also in great numbers, living freely upon the leaves or succulent growing shoots. No kind of tree is free from one or more species of these pests, and no sort of insect makes a more continuous drain upon the vitality of the attacked plant. Individually insignificant, their numbers make them dangerous, and their habit of excreting the plant juices in the form of "honey-dew" gives them the power of disposing of their food material more rapidly and in greater quantity than any other kind of insect. And they attack all parts of a tree: not only are they abundant among the foliage and branches, but even underground among the roots, and the latter are among the more serious forms. Of course, seasons affect the number of species and specimens of a species, to a very large extent. In wet seasons one set will become troublesome; in a dry season another will be in evidence while the former can scarcely maintain itself. And so of the trees: in some seasons plant-lice attack will be serious; in the ensuing, scarcely a trace of aphid injury may be found in the district.

Scale insects belong to the same general category as the plant lice in so far as they are suckers of the plant juices, but they are more dangerous because their attack is more continuous, because they are less exposed to adverse climatic conditions, and, perhaps, because some, at least, do exercise a really poisonous influence upon the plants. Soft scales are comparatively rare in the forest, and only the Tulip tree, *Liriodendron Tulipifera*, is seriously attacked in New Jersey. Of the armored scales the oyster-shell bark-louse, *Mytilaspis* species, is sometimes seriously destructive in the more northern sections on the walnut and butternut trees. Willow and poplar, which are also attacked, seem to stand the injury better. The nut trees are of comparatively slow growth, and when the twigs or smaller branches become thoroughly encrusted with scales, death is only a matter of time, usually a short time.

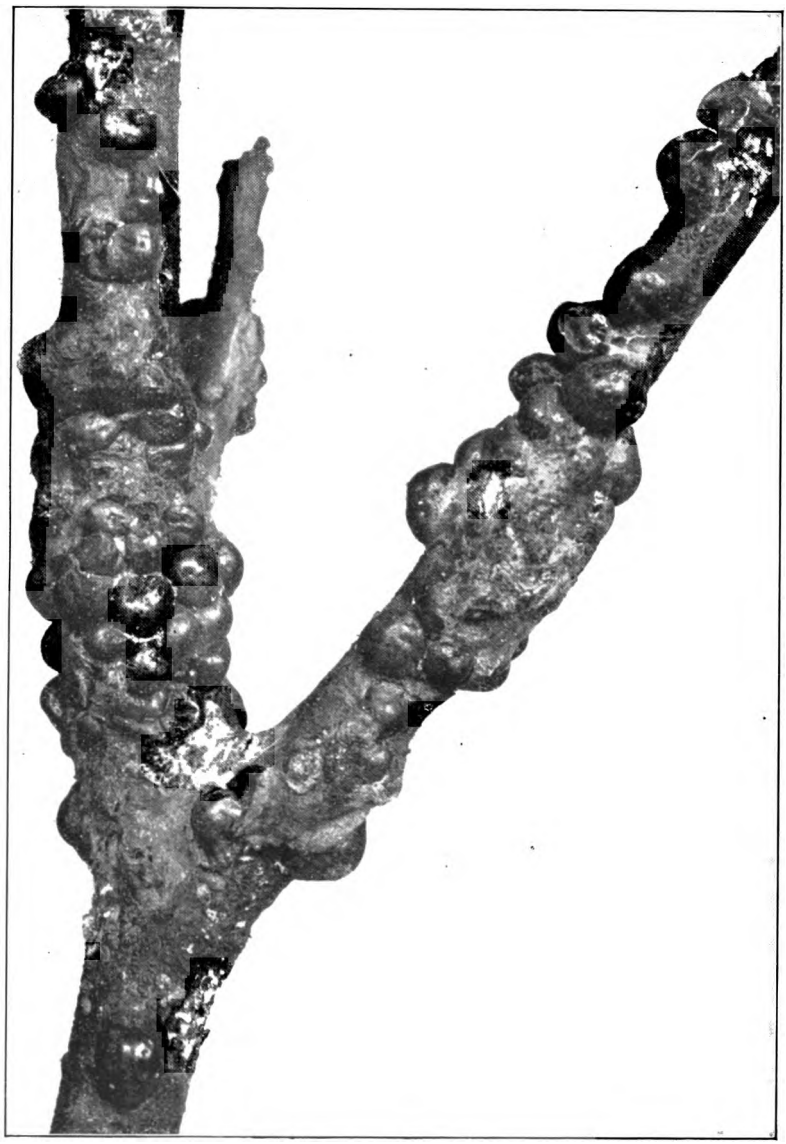

Plate No. XV.—The tulip soft scale, *Lecanium Tulipifera.*

Pine needles are attacked by a white scale, *Mytilaspis pinifolia*, that is responsible for disfiguring and considerably injuring trees in some parts of South Jersey.

There are, of course, numerous species other than have been mentioned; it is possible to indicate here only some of the principal types that may be commonly found feeding or living on the foliage and more actively growing portions of trees.

But the real enemies of the forest are not usually those that outwardly attack a healthy tree, though these do their share of harm; but the forms that lie in wait for the weakling, the maimed and the cripple, depriving them of the chance of recovery.

This is especially true in a State like New Jersey, where the forest areas frequently suffer from fires, large or small, from cattle, from careless cutting and from numerous other causes not found in primitive forest areas.

Send through a strip of woodland a fire that burns only the leaves and undergrowth, and does no more than scorch the trunk or kill an occasional branch, and watch the result. In a few weeks or months thereafter, according to the season, the undergrowth is renewed, and, superficially, the signs of injury have disappeared. Yet if we examine the trees themselves more carefully, we read another tale: wherever the bark has been scorched and killed, wherever a branch has been burnt, wherever twigs have been charred or deprived of life, and, in short, wherever a wound of any kind has been made, there we find that borers have entered. Little piles of sawdust at the base of the tree attract our attention, and if we trace them to their source we find little round holes, the size of a pin-head or thereabouts. These go through the bark and either into the solid wood or into the bast or sap-wood.

The culprits are "shot-hole borers," "bark-beetles," or Scolytids—little cylindrical beetles varying from less than one-sixteenth to an eighth of an inch in diameter and from one-sixteenth to three-sixteenths of an inch in length. Their work below the bark and into the wood gives entrance to moisture and germs of decay that weaken a larger area, in which the next brood finds a congenial home; and, coming out in numbers that cannot all find entirely suitable areas, they attack and

enter healthy wood, in which, while they may not be able to breed, they may be able to set up a condition of affairs that will afford a proper home for a subsequent horde.

Meanwhile, further from the injury, but affected by it because of a lessening or interruption of the flow of sap, flat-headed borers have gained a foot-hold. They have begun to form shallow chambers in the sap wood, in which they live one, two or three years, constantly enlarging their field of operations and driving galleries that further interrupt the flow of sap until they are ready to pupate. Then they bore a short distance into the trunk, lie dormant in the pupal stage for a shorter or longer period and finally emerge as adults, ready to reproduce their kind, preferring the tree they themselves fed upon for purposes of oviposition, if it is at all suitable. As a result dozens of galleries replace the few, water gains further entrance here and there and cavities beneath the bark become obvious. These afford shelter to a large series of species that do not directly injure the tree, but by bringing in excrementitious matter favor the development of decay germs. Fermentation sets in, and a host of flies and sap beetles are on hand at once to further the disintegration of wood fibre. Finally a sheet of bark becomes loosened and falls; then come another lot of borers into the heart-wood: Scolytids or shot-hole borers, round-headed borers, boring caterpillars, goat-moths or Sessiids, and in some instances ants or Termites, though these usually come when the fate of the tree is finally sealed.

Of course, the progress of the insect attack is slow or rapid, in proportion to the extent of the original injury. If the injury was at all extensive, as a scorching of one side for several feet, two or three years will suffice to doom the tree and place it in control of the scavengers whose duty it is to reduce it to dust. If it was limited, several years may be required, assuming that the tree does not succeed in scarring over the original wound.

As the trunk becomes the object of primary attack when the injury starts there, the effect on the crown may not be immediately noticeable. But any serious interruption to the flow of sap is bound to have an effect on the area that should be supplied through the injured tract, and at once the insects mark the weakness. Twig borers enter at the tips and kill the young

Plate No. XVI.—Burrows made by the hickory bark-beetle. This is a section of bark from a tree about 15 inches in diameter, killed by these insects.

shoots, or they may bore in at the base of the new growth, causing it to wilt; girdlers find the branches attractive, and a great variety of creatures, chiefly beetles and flies, with a few Hymenopterous species, perhaps, continue the attack from above.

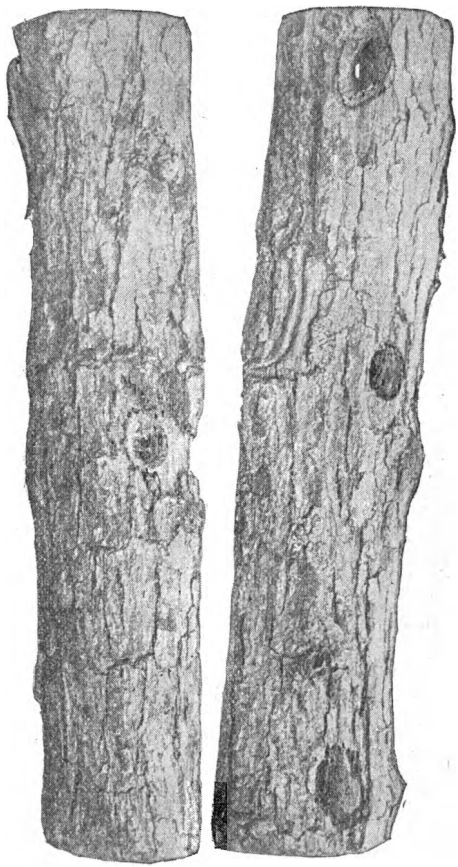

Figure 4.—A stick of oak, 4 inches in diameter, showing woodpecker holes made to get at a borer inside.

Now comes another factor—the woodpecker and its allies, that make war upon the borers. They peck and hammer away at infested spots, and many a fat borer falls prey to their activity and industry, but wherever they haul out a specimen they leave a hole, and that is, too often, an entrance point for the water, that, after all, is as much to be dreaded in the tree as it is useful when it reaches the roots through the soil.

Thousands of oaks in South Jersey, four to eight inches in diameter, are "doated" and useless except for short posts or firewood because of the well-meant efforts of woodpeckers to clear the tree of borers.

In this case the boring insect is the larva of the "goat moth," *Prionoxystus robiniæ*, and this makes a gallery about three-

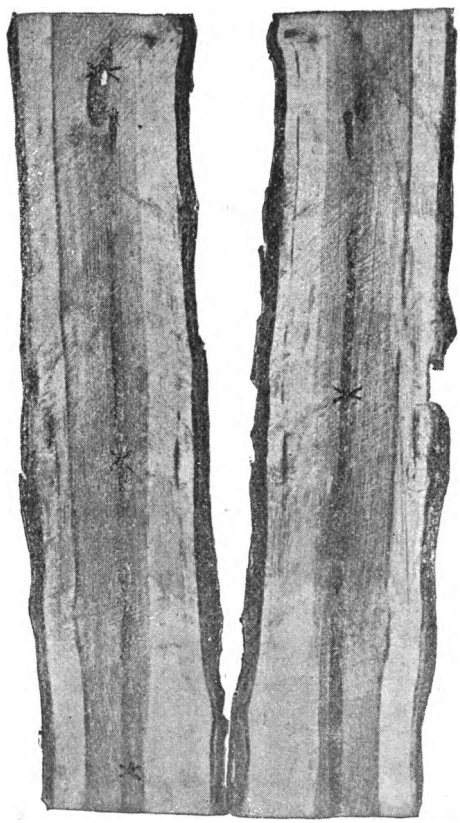

Figure 5.—The same stick as Figure 4, cut through to show the burrow made by larva. The X marks indicate where the woodpecker hit the burrow, in each instance needing two holes to get a larva.

sixteenths of an inch in diameter as nearly as possible in the center of the trunk. Our woodpecker locates this larva with great exactness and drills a hole two to four inches deep, about one and a-half inches square at the surface, and tapering to the diameter of the burrow. In most cases he gets his larva at the

first effort; but failure is not infrequent, and as many as four such holes may be drilled into a small tree from different sides before the grub is finally landed. A tree so treated is spoiled for all purposes save the wood-pile. It may recover, yet it will never completely outgrow the injury done—not by the larva, but by the bird.

The "goat moth," by the by, deserves more than a mere passing notice, because of the real injury done, not so much to the tree, as such, as to the timber that it should make. The insect derives its popular name from its peculiarly pungent and unpleasant odor, which is most intense in the pupal stage, and is, perhaps, protective. The moths are large, expanding from two to four inches, the wings more parchment-like in appearance than usual in this order, and the body in form somewhat like the hawk moths. They do not feed, fly chiefly at dusk or in the night, and are rarely seen even when the larvæ are abundant. Eggs are laid in some wound, preferably the very spot where a moth has already emerged, and the young caterpillars start from that point. A tree once infested, therefore, is likely to remain so, and at the point of entrance quite a decided swelling usually forms, in which is a more or less obvious scarred opening. The caterpillars are white or with a pinkish tinge, just a little flattened, with rather prominent black warts or tubercles, each of which bear stiff, bristly hairs. The head is large, brown, and with prominent jaws. When full-grown they are fully two inches in length, and early in the third year the pupa is formed in the gallery, near the surface, and preferably at just about the point where the entrance was effected. The borer is no great feeder, considering its size and length of life; its burrow rarely exceeding six or eight inches in length, of equal diameter throughout, so that the larva may move from one part to the other at all times. A young borer entering one of these old burrows may continue it upwardly, or may start a lateral from it, curving upward soon after he gets well away from the old one, and so a series of galleries may start from the one point of entrance, each year adding a little to the sum of injury and detracting as much from the value of the timber. Since they do not really interfere with the nourishment of the tree, they are not likely at any time to cause its

death, and I have seen examples where all external wounds were healed over years since, yet whose history of prior infestation was plainly to be read when the trunk was split, the old burrows found and the gnarled and twisted tissue of the old entrance laid bare. These defects are never repaired, and a burrow once made in the heart-wood of oak is there for all time.

Trees of this kind should be selected for firewood or for such purposes as they are suitable, and the sections containing the

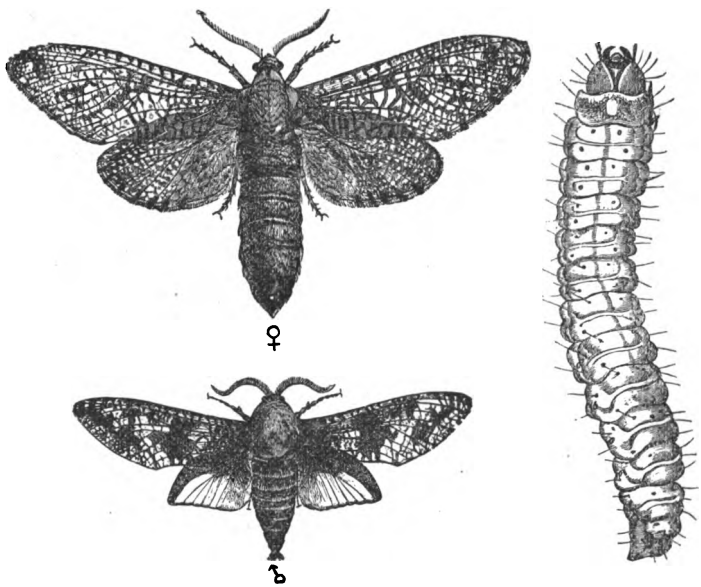

Figure 6.—Goat moths: female above, male below, and larva: from Riley.

larvæ should be used not later than June 1st, to prevent the emergence of the moths. The cutting should be done, of course, in winter.

Scrub land is peculiarly subject to insect injury when even a small fire has been through it. There are hundreds of acres of oak brush in South Jersey, and each year some portions are more or less scorched. The season following, almost every one of the shoots or saplings will be infested by round-headed borers of the genus *Elaphidion*, commonly known as "oak-pruners." Their normal habit is to bore into oak twigs or branches until they are full-grown, then to cut the twig from the inside until it

is held by a mere film of bark that will break in the first high wind, carrying the borer to the ground in a shelter that remains unchanged during the remainder of its larval and pupal life. In the injured oak-shoots the larvæ find ideal conditions for their development, and they seem to realize that here there is no necessity for girdling, because they make not the least attempt in that direction. These borers remain in the trees one year only, and after that the wood is no longer in the right condition for them; they leave it for others that delight in dead wood, and of these there is no lack. There is another consequence, however: where so many beetles develop they are hard put to it to find a place to breed, therefore they attack many trees that would, under ordinary circumstances, escape. Hence apple trees are frequently attacked and sometimes seriously injured, and large shade trees in parks and gardens are subjected to a merciless pruning.

I think I have indicated sufficiently that the natural tendency under normal forest condition is to eliminate the weakling and the cripple, and that insects are among the chief agencies by means of which this is accomplished. The hosts of species that feed upon or in the foliage are comparatively of little importance unless they strip the trees. This sometimes happens, and then the proper conditions may be induced that result in a successful borer attack.

These borers are of three kinds, the bark or shot-hole borers, Scolytids; the flat and the round-headed borers, Buprestids and Cerambycids respectively; all of which have been already mentioned.

The Scolytids are generally divisible into those that make galleries under the bark and those that work in the solid wood. The work of the former is most obvious, and their galleries, radiating from a single central channel, are obvious when a flake of bark is removed. Their method of causing injury is equally obvious; boring as they do between bark and wood, and partly in each, they interrupt the flow of sap, and when many of them are present, in effect, girdle the tree. These borers rarely attack healthy trees; but it does not need much to give them a foothold. Trees in parks, without proper supply of nourishment or in sod, on land too well drained, are often attacked and killed

when to all appearance they are sound as a dollar; and this may be so, too, where woodland has been too thoroughly opened up or where natural water-courses have been diverted and the usual supply of moisture has been either decreased or added to abnormally. When once these beetles have secured a good foothold the tree is doomed, and good forestry practice is to take it out and use it up immediately.

Almost every species of bark-beetle makes a gallery peculiar to it, so that to one familiar with their habits a look at their work tells the species even if no adult insect is available for examination. Yet there are certain features that most of them have in common; usually the female parent bores into a proper tree, through the bark to the sap wood, and in the layer between bark and trunk, though mostly in the bark, a vertical channel or burrow is made. A series of small chambers are nicked out at each side of this channel and in each of them an egg is laid. The larva, when hatched, at once starts a channel or burrow of its own, narrow and thread-like at first, but becoming larger as the grubs increase in size and each channel diverging from all the others so that they rarely cross. The pupa is formed at the end of this larval gallery in a little cell eaten out for that purpose, and the adults come out through little round holes bored by them when fully matured.

In some cases the central gallery is even throughout; sometimes there is an enlargement or an oblique spur at one or both ends, or a chamber somewhere in its course in which the parent can turn around if it so desires.

Of this type is the Hickory bark-beetle that at Glen Ridge, New Jersey, killed off so many trees a few years ago. (See Figure 4.)

The Scolytids boring in the solid wood are usually called shot-hole borers, because of the size of the hole and because the edges are generally blackened as by fire. The work of these beetles is not so obvious, nor is their ill effect so immediately visible as in the case of the previous type, yet they are always ready to do their share when the proper conditions arrive.

The typical shot-hole borers differ altogether in many respects from the bark-boring type. Their galleries go variable distances in the solid wood, then laterals no larger or longer than the

beetle itself are driven, and in these the larvæ develop. They do not lay so many eggs as the bark borers, but multiply rapidly

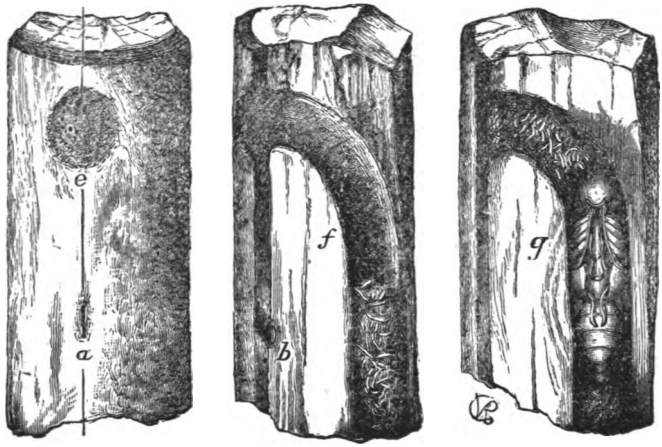

Figure 7.—Round-headed apple borer: *a*, puncture in which egg is laid; *b*, same in section; *e*, hole from which beetle has emerged; *f*, same in section; *g*, pupa in place.
From Div. Ent., U. S. Dept. Agl.

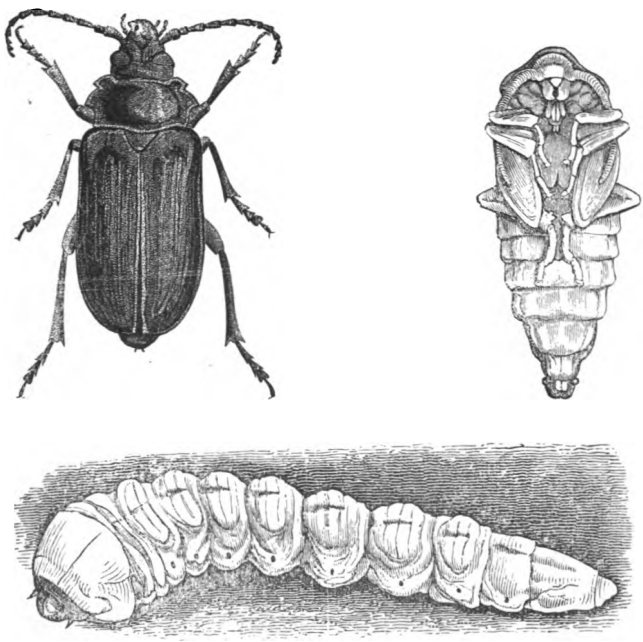

Figure 8.—Giant borers, *Prionus* species; larva, pupa and adult natural size From Riley.

enough for practical purposes. A very striking character in some species is that, while they really bore into the wood, yet the larvæ have to be fed by a peculiar fungous growth known as *Ambrosia*. All the real boring is done by the adults, and the galleries once seeded down to *Ambrosia* are inhabited by successive broods of species, the dark staining in the wood resulting as much from the fungus as from the work of the beetles. On small trees a number of these beetles working at or near the same place may so weaken the trunk that it will break in the first high wind that comes along.

Other species seem to prefer the very center of twigs, boring out the minute core in oaks and using the galleries thus made as a winter shelter.

The round-headed borers are more or less cylindrical, white or yellowish grubs, the segments usually very well marked, and the "head," or anterior portion, considerably enlarged or swollen. These forms frequently attack living wood, and bore, usually, in the solid tissue, though some may burrow, for a time at least, beneath the bark or in the bast. To this series belong the "oak pruners," the "twig girdlers," the "bark slippers" (concerning which more will be said hereafter), the "giant root-borers," and a variety of other pests. The adults are Longicorns, or long-horned beetles, and all are feeders in woody or stem tissue in the larval stage. As adults they are not injurious, and are apt to be found on flowers, though some species are distinctly rare even when their larvæ are not uncommon. Thus oak sprouts are attacked at the base by a borer which kills a large percentage of them each year, and this borer is not at all rare; but the beetle, *Goes tessellatus*, may be sought for years before even a single example will be captured.

As an example of the injury done by these longicorn borers, that attacking the locust may be cited. There is scarcely a locality in the State where these trees are not rendered utterly worthless by the attacks of these insects, and, while the trees may live under the attack for years, they are never good for anything. And this leads me to call attention to another point: the longicorn borers are mostly wood feeders, and when they attack healthy trees, as many of them do, they bore at once into the trunk or the body of the branch. If they work in the bast

or sap-wood at all, it is for a short time only in the early stages of growth. The tree derives its chief supply of nourishment through this bast and sap-wood, which is scarcely at all injured by these larvæ, hence they may work for many years without causing fatal results, if they are alone in their attacks. The Scolytid borers working the sap-wood or bast interfere at once with the nourishment of the tree, and the results are immediately noticeable. The result of this difference from a practical standpoint is that a tree killed by Scolytids may make fair timber; one that has been long infested by longicorn borers will be worth little or nothing, though the insects may not have killed the tree. The function of other of these borers attacking dead or dying wood will be again referred to.

Flat-headed borers resemble the round-headed forms in general shape, but are compressed and flattened, the "head" segments comparatively broader and the body somewhat longer, so that they have been called "hammer heads." These borers in the main attack weak, sickly or dead trees, though one group, the Agrilids, forms an important exception. They live chiefly just under the bark or in the sap-wood, forming irregular shallow chambers connected by short, irregular galleries. Some of them live two or three years in the larval stage, and, before transforming, bore a short distance into the wood to form a pupal chamber, issuing later through a hole in the bark, as do the longicorns. It is easy to determine at all times whether a tree has been infested by round or flat-headed borers, for in the first instance the exit hole is as round as if it had been bored by an auger, while in the latter it is regularly oval. The flat-headed borers come with or after the Scolytids, rarely before, and when the two are together present the flat-headed grubs often extend their chambers throughout an entire gallery system of a bark beetle, destroying everything in their way.

The adults of these borers are *Buprestids*, for whom there is no satisfactory common name. They are long and narrow, somewhat flattened, tapering posteriorly, very hard in texture and generally metallic in color. Some of them are bright green, or brilliantly copper gilt, but most of them are more soberly bronzed or have a metallic green or blue reflection.

The species of *Agrilus* are the smallest of the series, rarely more than one-quarter of an inch long, very slender and always

bronzed. Their larvæ are similar to those already described, but attack healthy plants, and, instead of excavating chambers, make long winding burrows, often completely girdling small branches and causing injury altogether out of proportion to their size. This reference to size also brings to mind the further fact that the larva in this case is excessively large in proportion to the size of the adult, an inch and a-half borer making a one-quarter-inch beetle. They are called sinuate borers, from the character of their burrows, and chestnuts are frequent victims, some forms also attacking orchard and small fruits.

Besides the Coleopterous borers just described, there are several boring caterpillars that may be always distinguished by having eight pairs of more or less developed legs. They bore in the solid wood as a rule, and rarely in sufficient numbers to cause actual injury. Their chief danger lies in the fact that they open the way for the other species that endanger the tree itself.

The goat moth, coming of the largest of these caterpillars, has been already mentioned. The others belong chiefly to the clear-winged moths of the family *Sesiidæ*. The caterpillars are more cylindrical than those of the larger species, and the head is usually black; otherwise they are very similar. The pupa is quite generally provided with a more or less developed chisel-like process to the head, by means of which it cuts its way through the bark. It wriggles through the opening so made until it projects half its length beyond the tree, being held in place by the rings of spinules and pointed processes with which the segments are set. The moths are usually black, marked with yellow, more or less resembling a wasp or hornet, and the wings are also narrow and transparent, to heighten the illusion. These borers are in many of the forest trees and occur in all parts—quite as often in the roots as elsewhere. In some cases city shade trees become the victims and the maple is particularly susceptible to attack.

Heretofore I have spoken of the species that attack the healthy, sickly or injured tree to cause its death, and this is one important way in which injury is caused to forests. Another kind of injury comes in when for any reason timber is killed purposely or dies standing, before being made into lumber. A dead tree is a carcass to be removed, and dozens of species and thousands of specimens begin work at once, the borers of course

doing the main work at the beginning and opening the way for decay and the species that further it. Species of all sizes will bore little holes, most of which blacken or discolor, and lessen the value of the boards into which the trunk may be cut. Then the larger galleries prevent its use for that purpose altogether. After the larger borers have made a good start, ants come in and occupy their galleries, extending and connecting them for their own guests and other messmates, which, though they do not directly feed upon the wood, yet open up new points for decay. Termites, or so-called white ants, come along and work at the surface or underground, and these are destructive when once started. They are typical wood-feeders, and their colonies contain countless numbers, reducing a tree to a mass of galleries in an astonishingly short time. When once these insects have made a fair start in a trunk, its value as timber is gone. In fact, it may be said that from the time life has ceased, standing timber deteriorates continually and ever more rapidly, primarily as the result of insect-attack.

If a load of cord-wood be cut in winter and piled, it makes an excellent collecting-ground the year following. From the time that spring is fairly open, beetles, flies, many Hymenoptera and some visitors of other orders flit about it, some seeking food or shelter merely, others a suitable point for breeding. In mid-June it will be a busy scene during the warm sunny hours, and all seasons new forms keep coming. During the latter part of the winter following it will be noted that much of the bark on the sticks comes off easily, and in the following spring it can be lifted off readily from the majority of them. Examination will show that the tissue between bark and wood has been completely eaten out by a series of larvæ which are called by the woodmen in some localities "bark-slippers." They are round and flat-headed borers, though the former predominate, and are mostly members of the genus *Phymatodes*, all of whose species have similar habits. Beneath this loose bark we find secondary species: members of the order *Thysanura*, spring-tails mostly, that occur wherever there is moist, decaying or fermenting vegetation of any kind. With these, and probably preying upon them, are the little pseudo-scorpions, or Chelifera, which may be found in all stages in early summer. Centipedes and milli-

pedes, the predatory and vegetarian types, find here both shelter and food, while sow-bugs (*Oniscus*) are found in the lower tiers.

The bark slippers, when they have attained their full size, eat a short distance into the wood to form a pupal chamber, whose entrance they plug up with shavings until they have reached the adult stage. Where tan-bark is made, these same species sometimes do considerable mischief, boring in the bark itself or between the layers, lessening its value and occasionally ruining it where left out-doors too long.

No wood can be too hard, too dry or too dead to secure it against borer attack, though its condition may often retard their

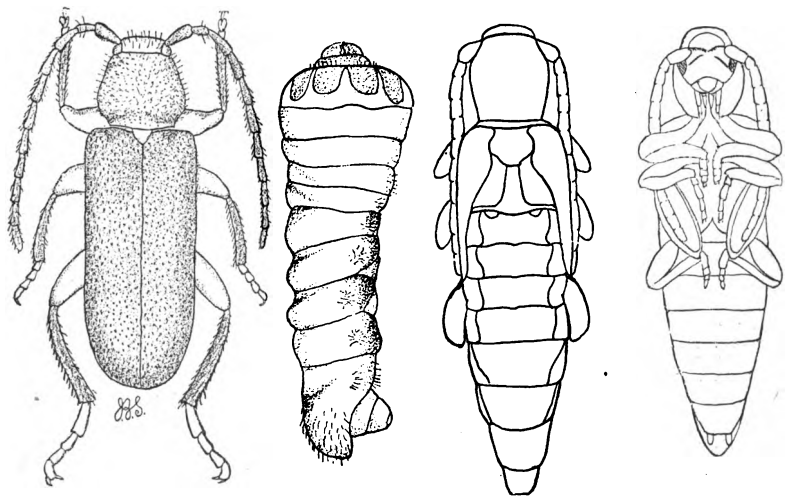

Figure 9.—A "bark slipper," *Phymatodes* sp., in all stages—larva, pupa above and below, and adult.

development. Larvæ that live in concealment and grow slowly, requiring two or three years to reach a stage which other insects attain in as many months, may, under favorable conditions, have their development greatly retarded. Logs may be cut up into boards, made into furniture, and come into daily use without harming the contained borers, some of which have lived for more than a decade under such conditions.

In March, 1898, the yellow-pine wainscoting of a building in Somerville was found to be filled with round-headed borers. It had been in place five years, and, when discovered, the insects

had bored out almost the entire center of each board, leaving only a mere shell. Of course the whole work had to be removed, and I secured some specimens, intending to raise the species to maturity; but, in October, 1899, the larvæ are yet unchanged and manifest no apparent desire to get into the pupal stage. This case demonstrates both the longevity of the insects and the damage caused by them.

A somewhat different case occurred in Jersey City, where hardwood timber had been made into paneling. The wood seemed in fair condition; part of it was veneered and all of it was filled, heavily varnished and polished. In the spring of 1898 the owner was astonished to find the little powder post beetle, *Lyctus striatus*, emerging in great numbers, leaving their small exit holes everywhere in such quantity as to utterly ruin the appearance of his trimming. The larvæ, in their early stages, had not been noticed when the material was worked up, and had developed normally after the woodwork was finally in place. It is difficult to cover wood so as to prevent beetles from *coming out*, but as a rule the insects need a recognizable surface for entrance and will rarely *enter* a varnished or painted board or post. Indeed, even lime will answer as an outdoor preservative, very few insects caring to bite into or even to come to rest on it. The latter, however, may be due to the fact that they are too conspicuous on such a white surface for their own safety.

A fallen tree or log left to lie in the forest first becomes a prey to bark slippers, as in the case of the cord-wood; but the bark remains in place and furnishes shelter to the host that is working beneath it. Click-beetles, and their larvæ, the wood-feeding wire-worms, come in, as do also the grubs of some of the weevils. These make surface burrows only, but in the heart-wood are the giant borers, both round and flat head, that make galleries nearly one-quarter of an inch in diameter. These attain a length of from 2 to 3 inches, and the resulting adults are the largest of their kind. The round-headed borer makes a species of *Prionus*, a stout black, long-horned beetle about 1½ inches long and half an inch in width across the shoulders. It is one of the species of slow growth and requires three years to come to maturity. Examples are most frequent in pine logs, living in the "fat," which without their assistance would resist decay indefinitely.

The wire-worms do not, as a rule, enter a tree or log until germs of decay are present, and they are not borers in the real sense of the word, except in soft or dry rot. The smaller species as a rule remain close under the bark and do not get into the body of the tree at all; but the larger species may be found wherever the tissue is soft enough to be penetrated by them.

The largest of all is about 1½ inches long and produces what is known as the eyed Elater, *Alaus oculatus*. It is over an inch long, loose jointed, gray and black speckled, the thorax with two very large eye-like black spots, one on each side, which attract attention whenever the insect is seen and make it easily recognizable.

The hammer-heads make a species of *Chalcophora* about an inch in length, not over one-fourth of an inch broad at the shoulders, tapering posteriorly, somewhat flattened above and more or less bronzed in color. These borers are not so long lived as the longicorn larvæ, and I know of no instance of their remaining in the larval state so many years under adverse conditions.

When water enters and decay has actually begun, another series of larvæ comes in—the "white grubs." White grubs are cylindrical, fat creatures, almost always curled up in a ring, with yellow or brown head, large, powerful jaws or mandibles, six well-developed brown legs and a very blunt posterior extremity. The creatures are clumsy in appearance and helpless when taken out of their burrows, their small fore body being incapable of properly supporting and balancing the clumsy, food-distended hind body. From the largest of these white grubs, distinguished by its ivory-like color and texture, comes our stag beetle, *Lucanus dama*, also known as the "pinching bug," because of the prominent mandibles of the male.

Gnawing at the roots of the stumps are others of these large grubs, from which come the "Rhinoceros beetles," so called because of the long horn on the front of the head, and others without a common name, species of *Strategus*, with horn-like processes on the thorax—formidable creatures all of them, in appearance, but actually harmless. It is not often that these insects are seen by the uninitiated, but they are, nevertheless, present, and are sometimes quite numerous in the Pines.

Exactly how much harm they do is perhaps a question. Their life history is not well known, and just how much living tissue the larva requires to bring it to the pupal stage is yet to be ascertained. It is reasonably certain, however, that they require two or more years to reach maturity, and that their presence alone does not indicate any serious danger to the trees.

There are other of these large grubs, feeding in decaying stumps, like the species of *Osmoderma*, black or brown in color, broad and a little flattened, with a peculiar, somewhat leathery odor, only a feeble indication of the intensely disagreeable effluvia of the giant *Dynastes* of the more southern States, which appears in New Jersey only as a very occasional visitor.

Smaller white grubs are nibbling away at the edges, so to speak, near the exposed ends of the log or trunk, leaving a little dry crust between themselves and the outer air. These are species of *Valgus* and allies, which, though they be common enough, are rarely seen except by the entomologist. When decay has proceeded well along, and the log has become unfit for most other species, the larva of *Passalus* comes along and does the finishing work.

This is also a white grub, grows to be almost two inches long, and differs from the others by having four legs only. The beetle is oblong, black, an inch and a quarter or more in length, somewhat flattened and with a little curved horn on the head, whence it derives its specific name, *cornutus*. When this insect gets through with a log or stump, it can be kicked to pieces without much effort, and of real wood fibre little is left beside the shell.

Stumps are in the same category with fallen trees and logs, the same general types of insects attacking them and causing their reduction to dust. Stumps, however, are more likely to be invaded by Termites, and when these take possession nothing else will be found. Ants, particularly the black and brown carpenter ants, are found in logs before they are much advanced in decay.

In this superficial sketch only the more prominent types of insects concerned in forest injury or in reducing a dead tree to vegetable mould have been mentioned, those forms chiefly that any one with a little ability in observing can find without much

trouble. The numerous types of Rove beetles, sap beetles, fungus beetles, &c., that are always found on dead and dying wood have not been even mentioned.

A fallen tree in the second season on the ground will occupy an entomologist an entire day in its exploration, and insects in some stage will be found in all parts of it; and each year brings different forms, adapted to live under the changed conditions until, when the woody mass can be crumbled between the fingers, the minute little *Scydmænids* and *Pselaphids* are sifted out over a cloth.

There is another set of insects that may have the effect of crippling or distorting a tree, as, for instance, the white pine weevil. This attacks the leading shoots of pine, fir and spruce, the larva boring into them and forming large cavities. When, as is usually the case, a number of the grubs are found in one shoot, it withers up and dies, leaving the plant to send out a new leader from another point. That, of course, destroys the symmetry of the tree, and a cripple results, of no value for ornamental purposes in a park and of little use for timber, should that stage be ever reached, for, once the victim of an attack of this kind, the tree seems predisposed to further injury of the same character, so that several leaders may be killed and the tree transformed into a mass of forks.

Another weevil larva attacks willow in much the same way, save that the infestation is more general, no "leading" shoots occurring in this tree. In fact, quite a number of weevil larvæ bore into twigs or branches or live beneath bark, causing local trouble, rather than general effect on the plant attacked.

The larvæ of weevils are somewhat like white grubs in shape, but much smaller, not so much curved, without the peculiarly rounded anal segment and without legs. The grubs found in chestnuts, hickory nuts and acorns belong to this tribe, and give a good idea of the general appearance of curculio larvæ.

It cannot be insisted too strongly that there is an insect host constantly on the watch to reduce to dust every tree that shows the least trace of flagging vitality, just as there is always ready a group of seedlings ready to take part in the struggle for the place vacated by a dead tree. It is indeed a continuous battle, not only between plant and plant, but between plant and insect, and, in

the long run, under normal conditions, both thrive. Both have their hard times and seasons of distress, and when one is up the other is down; but both maintain themselves. The object of the forester is to give his trees a little the advantage, to enable even the one low in vitality to make good its position, and to keep the wood product at the best and highest market value. To go into details is obviously impossible here, but some few suggestions can be given that will be useful where any attention at all is paid to woodland.

The first and most important feature is what corresponds to clean culture in the orchard and field; *i. e.*, the removal of all undergrowth and other material that would in any way interfere with the growth of the trees. This is often a matter of considerable importance where the soil is poor and the trees need all the advantage that they can get in the way of securing nourishment. It gives a better, healthier growth, offering no encouragement to insect attack, while the removal of the undergrowth deprives many forms of a shelter from which they await their chance to get at the trees.

It has a further direct advantage in that it removes altogether certain forms that attack the forest trees in one stage only. Thus a species of Ptinid beetle lives in the larval state in the roots of green or cat brier or in dead grape, the adults boring into the twigs of trees to obtain food and for shelter. The destruction of these briers removes one source of injury.

Freedom from undergrowth will facilitate other operations, in case of any unusual insect attack on the foliage. Complete defoliation by insects should be prevented at any reasonable cost, and it is rarely indeed that in our latitude this is threatened. Complete defoliation at any time means almost certain death to conifers; deciduous trees are not much injured by it, provided the terminal buds are not destroyed. They may be somewhat checked in growth and may in case of a drought ripen up prematurely, and have but a weakly growth the year following; but under ordinary circumstances, if defoliation takes place before midsummer, a new crop of leaves is produced in a short time.

Under the same general head of clean culture comes also the removal of dead and dying trees, and this is another very import-

ant measure. It has been already shown how great an attraction is a dying tree to boring insects, hence, as soon as it is discovered that a tree has become thoroughly infested, that tree should be at once cut out, removed and used up in some way, or if it cannot be at once used the bark should be stripped so as to expose the wood to the weather. This method will kill all insects which do not flourish in dry wood, and will, of course, prevent further breeding. The importance of this is not in the mere destruction of the insects in the one tree, but in the prevention of attack on the others. If a tree so infested be allowed to mature the larvæ in it, the resulting adults are apt to try other trees not naturally ready for them.

So a tree killed by girdling, by fire or in any other way, should be cut out as soon as may be to save the lumber in the best condition; the longer it stands the more holes there will be, and, of course, the less it will be in value.

Cord-wood made from live trees, in winter, should not be allowed to remain in the wood during the following summer, because in it so many insects will breed that may, when pressed, attack standing timber. In fact, the rule should be, broadly, to allow no dead or dying wood to stand or lie anywhere about, and the cleaning-up is best done in the early part of July, when the bulk of the wood borers are in the young larval stage.

It is good practice, also, to girdle a poor tree now and then, to attract what insects there may be about, serving thus as a trap and a protection to the other trees. This girdling should be done in winter for one set of insects, and in spring, after the trees are in full leaf, for another. Two trees thus treated will protect a considerable area of forest, and they should be cut out and destroyed the winter following.

Where a fire has been through any part of the wood, every tree, no matter how large or how small, that has been at all scorched, should be cut out. Such trees are almost certain to attract borers, and there is no greater ally or provider of insect food than this same fire. No shoot is so small that it cannot nourish some species, and to the entomologist and collector there is no richer ground for variety of species or number of specimens than a field of sprout-land through which a fire has run the year before. Hence such land should always be completely cleared for the protection of parts yet uninjured.

In general, birds are the foresters' friends, and should be encouraged; but I am not so sure about the woodpeckers. If there be no dead or dying trees no woodpeckers are needed to destroy larvæ, and on the other hand there is little likelihood that any will remain about where no chance for food-supply exists.

Frogs, toads, lizards and snakes are great entomologists, and destroy vast quantities of insects without in turn causing injury. Lizards, especially, destroy large numbers of wood-feeders, and should be encouraged.

Sometimes high winds, lightning or other causes injure or kill a branch or break it without harming the main tree, but leaving perhaps a ragged stump in case of breakage. All dead wood of this kind should be cut out, and all ragged stumps due to breakage should be properly trimmed off.

Direct insecticide applications are rarely practical in forest work, though in parks, where the trees have an ornamental value, they may become desirable. Against borers no applications can be made. The preventive measures already mentioned will suffice for them. The pruners or girdlers may be checked by systematically gathering and burning all the fallen branches in winter. This is really necessary on park land only, for the pruning done in the forest under normal conditions amounts to nothing, and natural enemies prevent too great an increase in the species. Isolated trees scattered in open groves are much more severely injured, and in such cases the gathering and burning of the pruned branches is indicated.

Where leaf feeders really endanger the tree or its foliage, particularly conifers, arsenate of lead will prove the best insecticide for general use, because of its harmlessness to foliage of all kinds.

Arsenate of lead is made by dissolving in water, in separate vessels, 4 ounces arsenate of soda and 11 ounces acetate of lead. The amount of water is immaterial, so it is sufficient to completely dissolve the chemicals. When the solutions are complete, combine the two and add water to make 80 gallons. This will kill most leaf-feeders in their early stages; but if the larvæ are well grown, or if adult beetles are to be dealt with, 40 gallons will be enough to use.

As to spraying machinery, pumps, nozzles, &c., that branch of the subject will be found treated in the reports and bulletins of the Agricultural College Experiment Station.

A very important method in European forest culture is banding with "Raupenleim" or similar sticky mixture impassible to caterpillars. This is employed chiefly against the larvæ of the Gypsy moth and the brown-tail moth, both of which now occur in the United States, but have not yet been found in New Jersey. At the present time there is no species against which such a method could be profitably employed in our forests, and it, as well as the allied method of trapping under cloth bands, requires more or less continuous attention. On a limited area of a park-like character burlap bands, such as are in use by the Massachusetts Gypsy Moth Committee, may prove useful as traps to many kinds of leaf-feeding forms that resort to it for concealment or for the purpose of pupation.

Such bands to be of any practical use must be examined at least once a week for the purpose of destroying what insects may be hidden there; hence their use presupposes a tract sufficiently valuable to justify the employment of some person sufficiently intelligent to exercise some discrimination in killing.

Finally, it may not be amiss to say that not one-fourth the damage actually caused by insects in our New Jersey forests could occur did not fires, great or small, first pave the way.